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Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

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1. Your reference NANOPAT 7

14FEB03 E785031-1 C86349
~~P01/7700 0.00-0303402.2~~

2. Patent application number *(The Patent Office will fill in this part)* 0303402.2

14 FEB 2003

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*
Dr DEREK ANTHONY EASTHAM
58 VINCENT DRIVE
CHESTER CH4 7RL
UK

Patents ADP number *(if you know it)* 08403628001

If the applicant is a corporate body, give the country/state of its incorporation

4. Title of the invention NANOSCALE COLLIMATORS FOR FOCUSSED ELECTRON AND ION BEAM MACHINES

5. Name of your agent *(if you have one)*

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

as above

Patents ADP number *(if you know it)*

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*
	0302591-3	5/2/03

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*
~~0302591·3~~	~~5 FEB. 03~~

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*
a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

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9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

(

Continuation sheets of this form	
Description	2
Claim *(s)*	1
Abstract	1
Drawing *(s)*	1 +1

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature D A Eastham

Date 12 FEB. 03

12. Name and daytime telephone number of person to contact in the United Kingdom

DEREK A EASTHAM
01925-603581

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Notes

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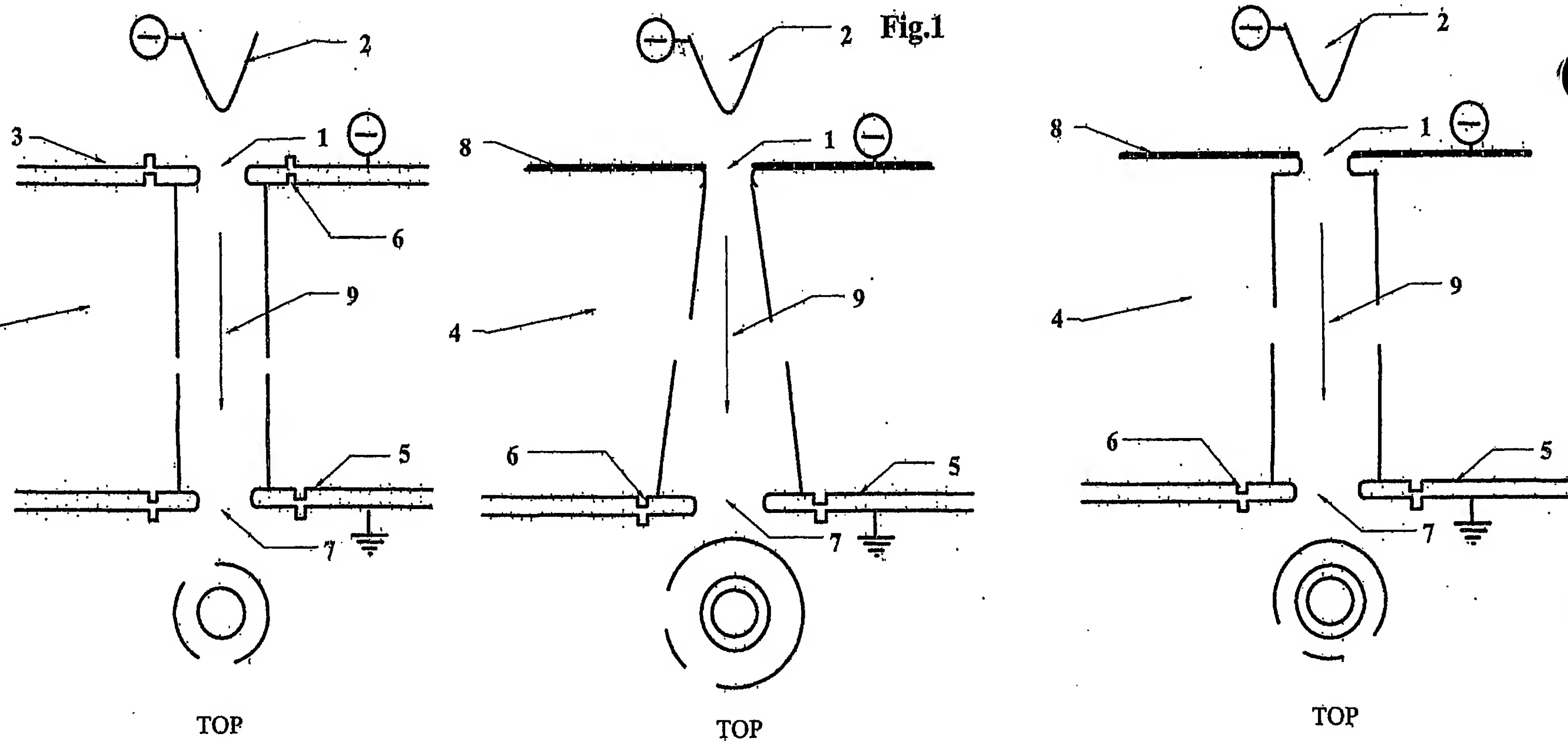
Fig.1



Abstract

Nanoscale Collimators for Focussed Electron and Ion Beam Machine

The collimation of electron and ion beams in nanoscale focussed electron and ion beam machines can be achieved using constricting apertures placed at various points along the beam path. These collimators need to have thickness in the nanoscale regime and have apertures less than 50nm for best performance.

Nanoscale Collimators for Focussed Electron and Ion Beam Machines

In a previous patent application (0302591.3) a nanoscale accelerator for focussed electron and ion beams was described. The key element in this device consisted of a thin wafer or film of silicon with a nanometer-sized hole through it. For the best performance, the diameter of the hole needs to be less than 100 nm and the thickness of the silicon larger than 0.5 μm. If this arrangement is to be effective, it is essential that the device contains collimators to both reduce the scattering from the walls (of the nanoscale hole) and to reduce the total emittance of the beam. The latter can be extremely important since the total emittance of the beam is proportional to the final beam spot size. Thus a large decrease in emittance brought about by using carefully chosen collimators can lead to a significant reduction in the final beam spot size. Two methods are available for producing collimators at the nanoscale. In the first method the nanoscale column has a conical hole in it with the smaller diameter hole closest to the nanotip electron source. In this way scattering of the electron beam from the inside walls of the hole can be largely eliminated. A conical shape can be replaced by a form in which the aperture of the hole is reduced more abruptly at the position where collimation is required. These collimators can be formed at both ends of the tube if needed. In another scheme, a thin metal covering layer at either or both end(s) of the hole is ion etched to produce a collimator. This can be done by dry etching techniques or using a focussed ion beam (FIB) milling machine.

General arrangements are shown in Fig.1, with the electron source being a nanotip, 2 at the entrance to the first nanoscale section of the microscope with the beam direction, 9, being marked. The left-hand diagram shows a section of material, 4, of micron thickness through which is fabricated a 50nm (typical size) circular hole by dry etching techniques. The walls of this hole can be made parallel if the etching is carefully controlled. The whole microscope column or assembly can be made with accelerating sections and non-accelerating sections as described in a previous application (0302591.3). One method of fabricating these apertures, 1 and 7, is as follows. During the production of the hole, registration features, 6, are produced on the surface to delineate the aperture position. The surface is then coated with a nanometer thick gold layer by vacuum deposition techniques (atomic deposition from a source) and a 2-3nm (typical) thick gold foil, 3 and 5, is placed over the aperture on

top of this first layer. (If this is done in clean conditions the gold foil will bond to the vacuum deposited gold layer on the silicon.) It is then possible to produce apertures, 1 and 7, in this metal foil by ion beam drilling or dry etching. (For this to be possible it is important that the registration remains visible after the gold layer is applied.) The central diagram shows an alternative way of producing an aperture particularly at the entrance to the accelerating section. In this method the hole is tapered as shown. This tapering can be produced by carefully controlling the dry etching process. The top conducting layer, 8, is then made by depositing a metal on the surface using standard vacuum deposition methods. A further aperture made by the previous method can be placed below this assembly as shown in the central diagram. However it is also possible to produce a collimator at this position by placing a second wafer with a tapered hole in it below the one shown in the central diagram. This then replaces the aperture made from thin film metal (gold). It can be made in a separate thin wafer (of silicon) which is positioned so that the holes are concentric or the whole assembly can be fabricated in one piece. Thus the system now consists effectively of two wafers with conical holes with both wafers vacuum coated on their flat sides with metallic films. It is also possible to produce a collimator from the intrinsic material of the wafer not necessarily in the form of a taper as is shown in the far right-hand side diagram of fig. 1. Collimators can be manufactured at either or both ends of the assembly or assemblies (wafers). These can be stacked to minimise scattering and/or reduce the phase space emittance of the beam.

Claims

A method of reducing the scattering and/or the emittance of electron (or ion beams) in nanoscale devices for producing focussed beams for microscopy or nanotechnology. This method essentially consists of nanoscale collimators (or restricting apertures) placed in the electron or ion beam path. These collimators are manufactured at the end(s) of nanoscale holes in thin films of material. The size of the collimators is important in determining their efficacy, as is the spacing of collimators along the beam path. The broad concept cover the following:

1) A range of aperture sizes for the collimators from about 1 nm to 1000 nm diameter but the greatest efficacy will be when the diameters is less than 50 nm for beams confined in nanoscale holes.
2) A key use of these collimators is when the first sections, after the nanotip of a focussed beam device, consists of a column of micron thick thin films (wafers) with nanoscale holes in them. The length of these sections can be from 0.1 μm to 10 μm and collimators can be positioned typically but not exclusively at these intervals along the beam path.
3) The collimators can be part of the actual nanoscale structures of the microscope (or device) and hence fabricated from the same thin film (wafer) material such as silicon.

4) The collimator geometry can be a tapered hole or any shape for which the surface exposed to the beam is significantly less than the inside surface of the hole.

5) Collimators made from thin metallic foil (gold) can also be used. These are mounted (supported) at the ends of the holes in the nanoscale sections of the microscope. To make covering metal foils other than gold, then a carbon foil 2 nm thick is first placed over the aperture and a metal layer is then deposited on this supporting foil using vacuum deposition techniques.